STATUS OF MINERAL RESOURCE INFORMATION FOR THE SPOKANE INDIAN RESERVATION, WASHINGTON

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SUMMARY AND CONCLUSIONS

Mineral occurrences on the Spokane Indian reservation include important uranium deposits and lesser precious metal, base metal, tungsten, antimony, molybdenum, and manganese deposits. Nonmetallic resources include barite, quartz, feldspar, silica sand, limestone, dolomite, marble, fibrous tremolite, sand and gravel, and coal.

Uranium offers the greatest mineral potential on the reservation and is currently being studied by the U. S. Geological Survey and private companies. The reservation also has potential for tungsten, base and precious metals, and nonmetallic minerals and further study of known occurrences is recommended. Potential for oil and gas is low.

INTRODUCTION

Geographic Setting

The Spokane Indian Reservation is near the south end of the Huckleberry Mountains in southwestern Stevens County, Washington (Figure 1). It is bounded on the west by Franklin D. Roosevelt Lake, on the south by the Spokane River arm of Franklin D. Roosevelt Lake, on the east by Chamokane Creek, and on the north by latitude 48º 01' (approximate). Its greatest east-west dimension is 30 miles and its greatest north-south dimension is 14 miles. The tribal headquarters at Wellpinit is about 42 miles northwest of Spokane, Washington.

The topography is generally rolling and gradual except near the Spokane River and the Huckleberry Mountains. Altitudes range from 1,289 to 4,208, but most of the reservation is between 1,800 and 3,000 feet above sea level. The climate is semiarid with most of the precipitation occurring in the winter months.

PRESENT STUDY AND ACKNOWLEDGMENTS

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GEOLOGY

General

Five main groups of rocks crop out on the Spokane Reservation (Figure 2). The oldest are metasedimentary rocks (phyllite, slate, schist, marble or calc-hornfels) of Precambrian age. Included in this group are greenstones which were intruded into the sediments as igneous sills; these are probably Precambrian. The ages of these rocks, determined by isotope measurements, are in the range of 700 to 1300 million years old. Cambrian sedimentary rocks unconformably overlie the first group. The unconformity is evidence of erosion and deformation in the interval between the formation of the Precambrian and Cambrian rocks; the latter are about 500 million years old. The third group consists of small bodies of granite and pegmatite that belong to the Loon Lake batholith which underlies much of Stevens and Spokane Counties. These intrusives are about 100 million years old. The fourth group consists of lava flows, volcanic tuffs and sedimentary rocks of Tertiary age, which formed in two periods of volcanism about 50 and 20 million years ago. The youngest rocks are poorly consolidated sand, gravel, and clay of glacial and fluvial origin. These formed during the Quaternary--within the past 3 million years.

Two structural features control rock distribution on the reservation. The mountainous north central region consists of metamorphosed sedimentary rocks folded about a north-trending anticlinal axis. Volcanic rocks which are abundant along the Spokane River and in Enterprise Valley probably are related to a major fault zone trending northwestward through these areas.

Rock Units

The distribution of rock types is shown on the generalized geologic map (Figure 2) adapted from the maps by Weaver (1920), Becraft and Weis (1963), and Griggs (1966). Table 1 summarizes the stratigraphic sequence of the rock units. The following rock descriptions and their distribution is abstracted mainly from Becraft and Weis (1963).

Precambrian Rocks

Togo Formation.--The oldest unit in the area, the Togo Formation, is metamorphosed sedimentary rock. Most of the formation consists of silver-gray to black, thinly-bedded, argillite and phyllite. Near granitic intrusions the rocks are schistose and coarser-grained with dark- and light-colored laminations. The phyllite contains local beds of quartzite one or two feet thick.

Bedding in the phyllite generally strikes about N. 10 E. and dips range from about 45º W. to 45º E. The eastward dips are thought to be the result of overturning during folding and result in younger beds lying below older beds. Small displacements in the plane of bedding are common and produce a foliation that causes the rock to split very easily. Locally the foliation is not parallel to bedding--this occurs in small scale drag folds related to major folding in the region.

The uppermost part of the Togo Formation is massive quartzite. This quartzite, about 600 to 1,600 feet thick, is an important geologic maker because of its distinctive appearance and good exposures. During metamorphism the quartz grains were recrystallized to produce a very hard, strong rock, consisting of nearly pure quartz.

TABLE 1
Stratigraphic Sequence of Rock Units

Alluvium Glacial deposits Palouse Formation	Quaternary
Columbia River Basalt Gerome Andesite	Tertiary
Porphyritic Quartz Monzonite Granodiorite	Cretaceous
Old Dominion Limestone Addy Quartzite	Cambrian
Greenstone (intrusive) Stensgar Dolomite McHale Slate Edna Dolomite Togo Formation	Precambrian

Calcareous rocks are locally present in the Togo Formation. There are good exposures of white marble and calc-silicate hornfels, formed by metamorphism of limestone, on the south side of Spokane Mountain and in an open pit at the Midnite mine. Calcareous rocks are also present in the valley of Sand Creek, but are poorly exposed because of weathering. The calcareous rocks are commonly dark colored but are bleached to brilliant white by contact metamorphism. The metamorphosed rocks contain diopside, garnet, idocrase, wollastonlte, phlogopite, epidote, calcite and quartz.

The Togo Formation is the host rock for uranium minerals at the Midnite mine and contains anomalous amounts of uranium in many other places. Phyllite and schist are the most common host rocks, but an important ore body occurs in calc-silicate hornfels. It would be of great help in exploration if specific parts of the Togo could be identified as favorable for uranium. However, the calcareous units are not continuous for more than about a mile, and it has not been possible to define specific stratigraphic attributes of phyllite and schist host rocks for their recognition in other parts of the reservation.

The Togo Formation is believed to be the same age as Belt rocks in eastern Washington, Idaho and Montana. Age correlations are complicated by lack of exposure in many broad valleys and by likely faults in those valleys, but it is probable that the Togo is equivalent to the upper part of the Belt Group. Belt group rocks may be envisioned as having formed in a large basin at the edge of the ancient continent. The Togo formed in the westernmost part of the basin in deeper water, as the Togo phyllite must have been black mud prior to metamorphism. Calcareous rocks in the Togo would have formed in local areas, such as reefs, where streams carried only little detritus. The quartzite unit of the Togo may have formed in shallower water close to shore similar to a modern beach.

Edna dolomite.--The Edna dolomite conformably overlies the Togo Formation in a north-trending belt about ¼ mile wide and four miles long in the Huckleberry Mountain region of the reservation. On the reservation the Edna ranges in thickness from about 2,500 feet at the north to about 1,300 feet at the south end where it becomes covered by younger volcanic rocks. The formation is poorly exposed because dolomite weathers readily. A characteristic feature is the formation of reddish-brown soil over the dolomite. On Figure 2, the Edna dolomite is included with other Precambrian rocks in the unit labelled "Precambrian undifferentiated." Although the Edna is dominantly dark-colored dolomite, quartziteand slate units as much as 400 feet thick are present also. The quartzite and slate units are discontinuous and have strike lengths of about 1 ½ miles.

McHale slate.--A north-trending belt of slatey rocks about three miles long overlies the Edna dolomite in the north central part of the reservation, and continues northward beyond the reservation. Beds typically dip about vertically, and strike about N. 20 E. The unit is about 2,400 feet thick at the north reservation boundary, but thins to 750 feet at the south end.

The McHale is typically a fine-grained, brown- to greenish-gray rock with well-developed slatey cleavage that diverges from the plane of bedding by 5 to 50 degrees. Where there are alternating beds of green and tan colors up to ½ inch thick, bedding is easily distinguished from cleavage.

Stensgar dolomite.--This formation is very important in Stevens County because it contains all known economic occurrences of magnesite. It is probably present in a very small area of the reservation. There are no exposures and its presence is inferred by projecting field relations a short distance from the north. Near Chewelah the Stensgar Dolomite is 730 feet thick, but is thinned to O feet by the pre-Early Cambrian erosion in the reservation area.

Intrusive greenstone.--Fine-grained dark green rocks intrusive into Precambrian rocks are exposed in many places on the reservation. Typically these are narrow bodies 5 to 20 feet thick and are conformable to bedding in adjacent rocks. Local cross-cutting relations demonstrate that the greenstones are igneous dikes and sills.

The greenstone was originally basalt or diabase. Metamorphism has converted the original minerals to hornblende, plagioclase feldspar, quartz, biotite, and chlorite. Mangetite is generally abundant, up to about 3 percent, and is locally replaced by pyrite.

The greenstone intrusives are interpreted to be of Precambrian age because they do not occur in younger rocks. These dikes and sills may have been feeders for lava flows in the Huckleberry Formation, which is exposed north of the reservation.

Cambrian

Addy Quartzite.--This hard, massive formation forms conspicuous ridges in Stevens County, and on the reservation forms the ridge which includes Boundary Butte. The southernmost exposure of Addy quartzite is atop Lilienthal Mountain, south of the Spokane River. Addy is about 3,900 feet thick, of which about 1,000 feet is phyllite. It strikes about N. 20 E., and dips about 80 W.

Quartzite beds are composed chiefly of medium-size quartz grains which are very well cemented together. Color is white to gray pale brown. Ripple marks and bedding features in the Addy indicate shallow water deposition. Phyllite beds are fine grained, green to brown colored, and locally display good cleavage.

Fossils of Early Cambrian fauna have been identified in the Addy north of the reservation (Okulitch, 1950). These are the only fossils known in the area and provide an important age reference.

The Addy rests unconformably upon Precambrian rocks. Erosion or to deposition of the

Addy removed as much as 8,600 feet of rocks from the Precambrian section. During this time interval the Precambrien rocks were tilted about 15 prior to deposition of the Atty.

Old Dominion Limestone.--This formation, about 4,400 feet thick on the reservation, conformably overlies the Addy quartzite on the western flank of the Huckleberry Mountains. Outcrops are rare because the limestone weathers easily. The Old Dominion is recrystallized to a brilliant white marble near granite intrusions, but is dark gray to black elsewhere.

Paleozoic(?) metasedimentary rocks.---Metamorphosed sedimentary rocks of uncertain age occur in isolated blocks south of Wellpinit Mountain and in the western part of the reservation. Because these rocks overlie granite intrusions they are well metamorphosed, a factor which complicates recognition of their stratigraphic identity. Graywacke, chert, and limestone units are present but their stratigraphy identity is not known. South of Wellpinit Mountain are quartz-mica hornfels and calc-silicate hornfels derived from quartzite and limestone. Weaver (1920) identified areas of schist and argillite at the west end of the reservation, which he classified as "undifferentiated argillite of Paleozoic age." These rocks possibly could be as old as Precambrian by present stratigraphic nomenclature, but probably are of Paleozoic age and equivalent to one of the several rock units identified by Campbell and Raup (1964) in the Hunters quadrangle, north of the reservation (Figure 1).

Cretaceous rocks

Loon Lake Granite.--A very large body of igneous rock, the Loon Lake batholith, is exposed over large areas of Stevens County and is presumed to exist at depth below most of Stevens and Spokane Counties. The batholith consists of many individual plutons of differing composition. Proportions of quartz,feldspar, biotite, and amphibole vary considerably. Recent geologic mapping and radiometric dating of minerals from many plutons in the batholith indicate that the bodies formed over a span of time from about 200 to 50 million years ago.

Granodiorite.--Large exposures in the eastern half of the reservation are of massive, medium--grained granodiorite. The medium-gray color is caused by relatively abundant biotite and hornblende mixed with abundant feldspar and quartz. The granodiorite weathers to a rounded or bouldery surface. It is well exposed on ledges above the Spokane River along the road to Little Falls. East of Wellpinit it is overlain by lava flows and gravels.

The granodiorite is a large body of rock of relatively uniform composition. It is cut by many dikes of light-colored aplite and pegmatite composed chiefly of quartz and feldspar. The granodiorite contains about 25 percent quartz, 35 percent plagioclase, 10 percent potassium feldspar, 10 to 15 percent biotite, 10 percent hornblende, and small amounts of apatite, magnetite, zircon, and sphene. Chemical analyses demonstrate that the granodiorite contains more calcium, magnesium, and iron than other Loon Lake granitic rocks.

Porphyritic quartz monzonite.--This rock unit is extensively posed in the central part of the reservation, along the road between Turtle Lake and the Midnite Mine. This rock is distinctive because its porphyritic texture with potassium feldspar phenocrysts one to x inches long. Color is generally pinkish gray to tan. Glossy black crystals of biotite are commonly visible. Dikes of aplite and pegmatite are common.

This rock is quartz monzonite because it contains approximately equal amounts of plagioclase, potassium feldspar, and quartz. It is lighter colored than the granodiorite because it contains less biotite, but 5 percent, and no hornblende. Muscovite occurs in much of this rock. Chemically, the rock contains more sodium, potassium, and silica but less iron, magnesium, and calcium than the granodiorite.

The porphyritic quartz monzonite is adjacent to the uranium posits at the Midnite mine and at several prospects. A possible reason for this relationship may be that the porphyritic quartz monzonite contains more uranium (average amount 12 parts per million) than the granodiorite (average amount 2 parts per million). This will be considered again in the section on uranium resources.

Quartz monzonite.--Several large and small bodies of equigranular quartz monzonite occur on the reservation. These are generally light--colored, fine-grained rocks, although local variants have large crystals or more mafic minerals. The largest body is 3 miles long near the Germania Consolidated mine. A smaller, finer--grained body is two miles north of the Northwest Uranium mine.

These rocks are characterized by roughly equal amounts of quartz, plagioclase and potassium feldspar, small amounts of biotite, and by the presence of about 2 percent muscovite. Contacts with the porphyritic quartz monzonite are gradational, indicating that both of these rocks are derived from the same magma.

Rhyolite.--Small, poorly exposed, rhyolite bodies occur in the sand Creek area of the reservation. These are very fine-grained, white to yellowish-gray rocks in which the only visible mineral is quartz. The rhyolite is compositionally similar to some dikes in the Loon Lake granites, and has generally been considered to be related in age and origin. However, the vastly different texture of the rhyolite could indicate emplacement at shallower depth in Tertiary time.

Tertiary rocks

Gerome Andesite.-- Volcanic lava flows, pyroclastic deposits, and related feeder dikes are abundant in the southern and western parts of the reservation. These rocks are in two main belts;

one extends northward from the Spokane River near Fort Spokane to Hunters, the other trends northwestward from the southernmost tip of the reservation at the Spokane River to Enterprise Valley (Figure 2). Gerome lava flows from rugged, conspicuous outcrops above the Spokane River whereas tuffs and pyroclastic deposits near McCoy Lake form gentle valleys because those rocks weather readily.

Lavas of the Gerome are dark shades of greenish to purplish brown. The rocks are massive and craggy because individual lava flows are about 75 to 100 feet thick. To the east of McCoy Lake total thickness is at least 1,500 feet. The unaided eye can generally discern phenocrysts of shiny black hornblende or augite which are set in a dense gray matrix.

A variety of other extrusive rock types recognized in the Gerome are tuff, tuff-breccia, tuffaceous sandstone and conglomerate. Carbonaceous shale beds are locally interbedded with the pyroclastic rocks. These rocks are well exposed at the Northwest Uranium mine. Geologic relations there indicate that conglomerate, tuffaceous sandstone, and carbonaceous shale were deposited by streams in a depression that may have been eroded by earlier streams (Becraft and Weis, 1963, p. 63). Stream-laid volcanic deposits of this variety are promising locations for undiscovered uranium deposits

Dacite dikes cut granite and older metamorphic rocks in many places. The dikes are generally north-trending with a steep dip and are a few feet wide and several hundred feet long. Chemically and mineralogically the dikes are similar to Gerome flow rocks.

These rocks are the oldest non-metamorphosed sedimentary rocks on the reservation. Clearly there was a great amount of erosion in approximately 50 million years prior to deposition of the Gerome on the granites. Fossil leaves and pollen from the Gerome have been identified as Oligocene.

Columbia River Basalt.--Basaltic lava flows fill depressions in extensive areas of eastern and western parts of the reservation. These lavas are part of the vast expanse of volcanic rocks south of Spokane and Columbia Rivers. The flows are well exposed in cuts between Wellpinit and Turtle Lake, and a mile east of pinit.

The Columbia River basalt occurs in erosional depressions cut the Loon Lake granite and the Gerome andesite, and is locally more than 900 feet thick. The upper surface is consistently near feet elevation except where eroded. This rock probably covered much more of the reservation, but has been removed by erosion in many places. Glacial deposits cover the basalt in many valleys.

The basalt is a dark gray to brownish-black rock of such fine grain size that generally no minerals can be recognized. Many joints (cracks) developed in the basalt as it cooled, resulting in irregular, blocky patterns. In places hexagonal "columns" developed. The jointing and hard character of the basalt aid in the development large piles of talus below outcropping ledges.

Southeast of the reservation the Columbia River basalt overlies and is interbedded with sedimentary rocks which contain plant fossils indicative of a Miocene age. The basalts are thus about 15 million old.

Quaternary deposits

Four kinds of flat-lying, unconsolidated deposits of Quaternary age occur on and near the Spokane Reservation: (1) the Palouse formation; (2) deposits from glaciers and glacial lakes; (3) alluvium; (4) landslides.

Palouse formation.--The Palouse consists of silt and fine sand was transported by winds. This formation overlies large areas of the Columbia plateau in eastern Washington where it is extremely important as a fertile soil for agriculture. It has not been identified the reservation, and is known in only a few places north of the Spokane River. It is apparently preglacial because no glacial gravels have been observed below it.

Glacial deposits.--Glaciers in northern Washington deposited volumes of silt, sand, and gravel in lakes and moraines. In the Spokane River Valley glacial deposits are particularly thick. Evidently the Spokane River valley was the site of a glacial lake into which much sand and gravel was dumped by melting glaciers. The lake level was probably at a maximum elevation of about 2,500 feet.

Three miles north of Wellpinit an area of about five square miles consists of fine silt deposited in a glacial Lake Wellpinit (Becraft and Weis, 1963, p. 51). Probably the lake formed behind an ice dam near Turtle Lake and drained down Blue Creek when the ice dam broke.

In the eastern part of the reservation there are glacial deposits at two levels. One deposit is above Columbia River basalt at elevations greater than about 2,400 feet and formed relatively early in the glacial period, possibly while the Spokane River valley still blocked by ice. Other deposits are at about 1,800 feet in Chamokane Creek valley. These are younger deposits which probably formed after the lake in the Spokane River valley was drained.

Alluvium.--Local lowland areas are covered by Quaternary alluvium. The extensive areas are along Blue Creek, Sand Creek, and Little Chamokane Creek.

Landslides.--Landslides of two types exist on the reservation. One occurs in glacial deposits along the Spokane River. Variations in the level of Roosevelt Lake trigger numerous landslides along the lake. Because of the potential for new landslides, buildings should not be erected close to the edge of embankments along the lake. Another type of landslide deposit consists of blocks of Columbia River basalt which slumped down steep slopes into glacial-carved valleys such as the Chamokane Valley, and are known in some places as toreva-block landslides. Most have been partly covered by younger glacial deposits that have arrested their movement.

Structure

Folds

One of the major structural features on the reservation is a large fold involving Precambrian and Cambrian rocks in the Huckleberry Mountains. This fold is exposed in the north-central part of the reservation. From Bear Mountain on the east to Enterprise Valley on the west, the rocks consist of a succession of west-dipping Togo phyllite, vertical-dipping Togo quartzite, Edna Dolomite, McHale Slate, and Addy Quartzite with nearly vertical dip, and finally the Old Dominion Limestone with westward dip. The ages and attitudes of the rocks indicate that this must be an anticline with the east limb overturned. The fold is intruded in several places by plutons of the Loon Lake Granite. There is no evidence that the granites were forcefully emplaced and caused the folding. Therefore, the age of the Folding is limited to that period between Cambrian and Cretaceous. Folding of rocks in north-central Washington is believed to have occurred in Triassic to Jurassic time, an age consistent with geologic evidence on the Spokane Reservation.

Smaller folds, a few feet in amplitude, are exposed in road and mine cuts. These folds are caused by drag in weak beds caught up in the major fold deformation. These drag folds indicate considerable complexity in the major fold that otherwise appears simple. Axial planes of the drag folds dip vertically to steeply east, and strike northerly. Fold attitudes near the Midnite mine indicate a major anticline axis lies to the west of the mine. There is also evidence for local tight folding within the major anticlinal structure.

Faults

Rocks on the Spokane Reservation are not extensively faulted. Faults older than the Loon Lake Granite might be covered by younger rocks. These are pre-Cretaceous faults recognized north of Springdale, Washington; these or similar faults could extend southward into areas there only younger rocks are exposed. Likewise, north-trending faults of large displacement have been identified east of Hunters, and these might extend south to the reservation in the Enterprise Valley area.

Intrusion of the Loon Lake Granite plutons caused faulting with minor displacements. Examples of these faults may be seen near the Midnite mine and on Cayuse Mountain. These types of faults commonly are effective ore controls, and probably were important in localizing ore at the Orazada, Germania Consolidated, and Midnite mines.

A younger fault cuts the Gerome Andesite in the Northwest uranium mine, and another shears a Gerome feeder-dike in the Midnite mine.

Topography and the distribution of the Gerome Andesite suggest a possible fault extending north-westerly along the Spokane River and through the Enterprise Valley.

MINERAL RESOURCES

General

Along the Huckleberry Mountain range are a number of old mining districts which were first active in the early 1890's. The Cedar Canyon (Deer Trail) mining district, an early producer of silver, copper, and lead with small quantities of zinc, antimony, and gold, is about three miles north of the reservation. This district is noted for its rich deposits. Substantial ore shipments containing 150 to 400 ounces of silver per ton are recorded as are shipments of copper ore assaying more than 7 percent copper with some values in silver ant gold. Production records for the Cedar Canyon district are incomplete but one of the properties, the Deer Trail mine, reportedly produced more than $3 million worth of silver during a period when the value of silver was only about one-fifth its present price. The mineralized structures of the district protect into the reservation. The three veins of the Germania tungsten mine were mined the northern boundary of the reservation. Production from this property alone has been more than $5 million at today's tungsten price.

Mineral occurrences on the reservation include the largest and most important uranium deposits yet found in the four Northwest States. Since the discovery of uranium in 1954, approximately 1,750,000 tons of uranium ore have been mined on the reservation. Almost all of the production has been from the Midnite mine where the ore has averaged 0.21 percent U_30_8.

Tungsten, silver, copper, lead, zinc, antimony, molybdenum, old, and manganese also occur. Incomplete records list mineral production as follows: tungsten, $135,000; silver, 805 ounces; copper, 51,697 pounds; gold, 5 ounces; and lead, 697 pounds.

Nonmetallic resources include barite, quartz, feldspar, silica sand, limestone, dolomite, marble, fibrous tremolite, sand and gravel, and coal.

Geologic Controls

Metallic mineral resources have generally come from four geologic environments on and near the Spokane Reservation, and are 3 follows:

(1) Fault and shear zones in Precambrian metasedimentary rocks, as in many base and precious metal mines and prospects in the Huckleberry Mountains.

(2) Veins and disseminations in contact metamorphic aureoles of granite plutons, as at the Midnite mine.

(3) Vein and disseminations within the granite plutons, as at the Spokane Molybdenum Mine and Germania Consolidated Mine.

(4) Disseminations in sandstone and conglomerate of the Gerome Andesite, as at the Northwest Uranium mine.

The following descriptions are taken largely from Weaver (1920), Huntting (1956), and Becraft and Weis (1963).

Faults and shear zones in Precambrian metasedimentary rocks have been important sites of metallic minerals in the reservation area. The O-Lo-Lim mine (sec. 9, T. 28, R. 37 E.), about a mile north of Sand Creek has produced copper and silver from a vein in Togo phyllite. The Orazada mine (sec. 27, T. 29 N., R. 37 E.) is in a fault breccia zone in the Edna dolomite; minerals consist of jamesonite (lead-iron-antimony sulfide), pyrite, arsenopyrite, galena, sphalerite, quartz, calcite, and barite. Copper, lead, zinc, and silver have been produced from similar setting in the Deer Trail, Togo, Queen, and other mines in the Deer Trail (Cedar Canyon) district about two miles north of the reservation boundary. These deposits may have formed from hot aqueous fluids circulating ln fault zones above granite plutons. More deposits of this type may be expected on the reservation.

Veins and disseminations of minerals in contact aureoles are physically similar to the deposits previously discussed but are much closer to igneous rocks. The spatial relationship is commonly cited as evidence for a genetic link to the igneous rock. In exploration the spatial relationship is useful in narrowing the target area to essentially a zone within a hundred feet to a thousand feet from a known pluton. The most important example of this type deposit is the Midnite mine (Figure 3). Others include the Lowley uranium lease (sec. 13, T. 27 N., R. 37 E.), Deer Mountain uranium prospect (sec. 21, T. 29 N., R. 38 E.), and the Alberta copper prospect (sec. 3, T. 28 N., R. 37 E.).

Uranium ore at the Midnite mine occurs in fault and shear zones cutting muscovite schist, mica hornfels, and calc-silicate hornfels of the Togo formation. Most ore mined to date has come from schist, but important orebodies are now being mined where the host rock is mica hornfels and calc-silicate hornfels. For the latter rock types small fractures of variable attitude, known as stockworks, contain most of the ore. Faults in the metasediments generally die out a short distance within the granite, and none contain significant ore the pluton. The general absence of ore, sulfide minerals, and hydrothermal alteration in the pluton raise questions regarding the genetic role of the granite pluton. Although problems of uranium genesis remain, it seems clear that deposits and prospects of the Midnite mine type are most common near the intrusive contract between the porphyritic quartz monzonite and the Togo formation.

A third type of ore occurrence is veins and disseminations within granite. The Germania Consolidated mine developed quartz-ferberite veins for tungsten; also present are molybdenite, scheelite, chalcolrlte, and bismuthinite. Similar quartz veins with tungsten and molybdenum minerals apparently occur at the Sand Creek prospect ,(recorded to be in sec. 3, T. 28 N., R. 37 E. by Huntting (1956), but is possibly mislocated). Quartz-molybdenite and quartz-base metal veins also occur south of the Spokane River at the Spokane Molybdenum, Fouress and Valley View mines.

Granitic rocks on the west and southwest side of Wellpinit Mountain (secs. 28, 33, 32, and 5) are hydrothermally altered and cut large quartz veins that have been prospected, but there has been no production. Few details are known about this area, but the general features observed could be indicative of vein or disseminated deposits depth. This area has potential resources of copper, molybdenum, lead, zinc, and silver, but these are highly speculative at present.

Pyroclastic and sedimentary rocks of the Gerome andesite are sites for the Northwest Uranium mine, known also as the Sherwood mine. In the mine area the Gerome consists of conglomerate, tuffaceous sandstone, and carbonaceous shale. The conglomerate, about 100 feet thick, contains boulders one to eight feet in diameter; the rock was apparently deposited very rapidly in an ancient stream valley. Uranium minerals are closely associated with layers and lenses of coal and carbonaceous material within the conglomerate (Figure 4). The orebody is bound on the west and south by faults, but these do not appear to have had a genetic role because they are neither mineralized nor bounded by hydrothermally altered rocks.

Formation of the Northwest uranium deposit was clearly related carbonaceous matter which reduced and precipitated uranium. deposits elsewhere in Montana and New Mexico formed in a similar manner. The source of the uranium is not known and could have been from any of several rocks. Uranium could have been released by weathering of Gerome tuffs, porphyritic quartz monzonite, earlier-formed deposits similar to those at the Midnite mine and then transported by ground water into the carbonaceous rocks where it was deposited. Uranium could occur elsewhere on the reservation in sedimentary rocks containing volcanic debris and carbonaceous matter. Radioactive anomalies in rocks of this type should be investigated carefully because the surface expression of an orebody the size of the Northwest may be deceptively small. Also, consideration be given to groundwater conditions; these rocks are commonly water-saturated aquifers, a condition that would impede mining.

Nonmetallic mineral resources of Stevens County occur chiefly sedimentary rocks. Magnesite deposits, about 10 miles north of reservation, formed in the Stensgar dolomite which is altered to magnesite. Lime or cement products might be derived from Precambrian and Cambrian limestones if suitable compositions could be identified. The Addy quartzite is mined for silica sand north of the reservation, but on the reservation the Addy appears to be too highly indurated to be easily mined. The Columbia River basalt is locally abundant useful as road metal. Glacial deposits are a good source of gravel and for local consumption.

Radioactive Mineral Deposits

The first commercial uranium deposit in the Pacific Northwest was found on the Spokane Indian Reservation in the spring of 1954 by Jim and John Lebret, Indian twin brothers. Although a number of other uranium occurrences were found in eastern Washington and Idaho, Montana, and Oregon, none were as large or as important as the Midnite mine deposit. To date this property has produced most of the uranium mined in the four northwest states. The following mines, leases, and prospects on and near the reservation are indicated on Figure 5 by corresponding number if on the reservation, or by appropriate symbol if outside the reservation:

1. Deer Mountain
2. North Star
3. Midnite Mine
4. Boyd Property
5. Lucky Charm
6. Dahl Uranium
7. Square Deal
8. Northwest Uranium
9. Big Smoke
10. Lowley Lease
11. Bair property

U Uranium occurrence (outside of reservation)

Midnite Mine

The Midnite Mine is in secs. 1 and 12, T. 28 N., R. 37 E., and in SW¼ sec. 6, T. 28 N., R. 38 E. The uranium ore occurs along the western contact of a tongue of schist, phyllite, and quartzite of the Formation, with porphyritic quartz monzonite. Uranium minerals are metaautinite, minor uranophane, phosphuranylite, coffinite, and uranite. Individual ore bodies are as much as 700 feet long, 200 wide, and more than 150 feet deep (Weissenborn and Moen, 1974, 8). Nine ore bodies have been developed at the Midnite mine and the adjoining Boyd property.

Dawn Mining Company, a Delaware corporation, was organized in the spring of 1955 to explore, develop, and operate the Midnite mine. Down 51 percent owned by Newmont Mining Company, and 49 percent owned by Midnite Mines, Inc. of Spokane, Washington. The Boyd property (Figure 5, no. 4), in sec. 12, T. 28 N., R. 37 E., adjoined the original Midnite mine property on the east and in 1956 became part of the Dawn Mining Company mining lease which now totals 691.27 contiguous acres.

A mining lease agreement, between Dawn Mining Company and the Spokane Tribe of Indians was made in September, 1955. Exploration proceeded and in late 1955, Midnite mine ore reserves were deemed sufficient to warrant mill construction. Large-scale milling tests were in the National Lead Company's pilot plant at Grand Junction, Colorado, and later at the U. S. Bureau of Mines Intermountain Station, Salt Lake City, Utah. Detailed mill design work started in mid-August 1956, and construction began later that year.

Production of uranium ore from the Midnite mine began in the spring of 1957 and milling operations began in August, 1957. During 1957, 592,000 tons of waste were stripped, 164,000 tons of ore were mined, 151,000 tons of low--grade material were stockpiled (Sheldon, 1959 p. 531). Mining was suspended in 1962, but the mill operated on stockpiled ore until July 1, 1965, to fulfill an Atomic Energy Commission contract. Mining resumed in September 1969 and ore was stockpiled until the mill resumed operation in January 1970 at a rate 500 tons per day. Since 1969, the Midnite mine has been producing slightly more than 100,000 tons of ore annually. Prior to suspension of operations in 1962, the mine produced 1,073,307 tons averaging 0.195 percent U_30_8; during the 1970-1975 period, the ore averaged 0.24 percent U_30_8. Newmont Mining Company's annual report for 1974, states the ore reserves at the Midnite Mine at the end of 1974, total 284,000 tons averaging 0.235 percent U_30_8.

Mining and exploration at the Midnite mine is done during late, spring, summer, and fall months. Company geologists and engineers plan the trenching and drilling, but the work is contracted mainly to a local drilling company. Exploration drill holes extend at least 50 feet into the quartz monzonite at the base of the ore body. Stripping of overburden and mining is contracted. Waste to ore stripping ratio has increased from less than 2:1 in 1955 to about 10:1 in late 1974. It is necessary to drill and blast the overburden beneath the weathered zone. Front-end loaders or 1 ½ yard shovels and trucks transport the rock away from the mine site.

Mining is by open-pit bench methods. Benches are maintained at 20-ft vertical interval and are at least 32 feet wide. Vertical holes are drilled with a 6-inch tricone rotary drill. Blasting is with ammonium nitrate and has produced a breakage of 1.4285 tons per pounds. Blasting must be carefully controlled, the ore only shaken, and not displaced with respect to waste rock. Ore is hauled 22 miles to the mill by diesel-powered 22-ton dump body semi-trailers.

The mill it a few hundred feet outside the reservation and about a half mile southwest of Ford, Washington. The designed mill capacity was 440 tons per day (t.p.d.), but was enlarged to 500 t.p.d. The character of the ore determines the actual capacity, which has ranged from 500 to as low as 390 t.p.d. A new short head cone crusher is to be installed at a cost of at least $100,000, and will increase the mill capacity. Feed to the ball mill will be minus ¼-inch instead of the present ½-inch feed. Required ball mill grind is 10 percent plus 65 mesh. The product is fed in series to seven, paddle agitated, 16 x 16 ft digestion tanks in which a sulfuric acid solution dissolves the uranium. Manganese oxide is sometimes added as an oxidizer. After 16 hours of digestion, the pulp is discharged through a counter current decantation (c.c.d.) circuit of four 40-ft. diameter thickeners. Tailings are 60 percent solids and are discharged from the last thickener to waste impoundment. The pregnant solution passes through a series of ion exchange resin columns which strip the uranium. The stripped solution is then recycled to the digesters. An acid ammonium nitrate solution removes the uranium from the resin and, after treatment to remove undesirable ions, the uranium is precipitated by ammonia. After thickening, filtering, and drying, the end product (U_30_8 yellowcake) is packaged in steel drums and trucked to Reardan, Washington, for shipment by rail (Hargrove, 1957, p. 7-15).

The recovery of the uranium depends upon the uranium content of the feed because the tailings consistently contain 0.007 to 0.008 percent U_30_8. For example, there is a 97 percent recovery from ore containing 5 pounds U_30_8 per ton, whereas there is only 95 percent recovery from ore containing 3 pounds of U_30_8 per ton.

Dawn mining Company obtains its water supply from natural springs on the reservation and use about 100 gallons per minute. Energy requirements of the Ford uranium mill are approximately 600 kV-A, but will rise to about 710 kV-A when the new short head crusher is installed.

Northwest Uranium Mine

The Northwest Uranium mine (Figure 5, no. 8) is 3 miles south of the Midnite mine in the SW ¼ sec. 35, T. 28 N., R. 37 E. It has been variously known as the Peters Lease, the Northwest Uranium mine, the Silver Buckle property and currently as the Sherwood Project now held by Western Nuclear, Inc. along with parts of secs. 34, 35, and 36, T. 28 N., R. 37 E. and secs. 1, 2, and 3, T. 27 N., R. 37 E. The initial uranium deposit was found in gently dipping pyroclastic and sedimentary rock of the Gerome Andesite. The ore consists of uraninite intimately associated with carbonaceous material near the base of a conglomerate that makes up the basal unit of the Gerome. Andesite in this vicinity. The maximum thickness of the ore body is 30 feet (Norman, 1957, p. 664-665). Small-scale open pit mining was employed. The mine was closed in March of 1963 and later that year the lease was assigned to Dawn Mining Co. In 1964, Dawn was granted termination of the lease which then reverted to the Spokane Indian Tribe.

Western Nuclear, Inc. obtained a prospecting permit from the Spokane Indian Tribe in 1966, and undertook a major exploration program which included 616 rotary drill holes, many to depths greater than 400 feet, in the proposed Sherwood Project area. This work was completed in 1968.

In 1971, Western Nuclear, Inc., started a heap leaching pilot test. After satisfactorily completing these tests, the facilities were removed and there was no further development work. However, Western Nuclear, Inc., and the Spokane Indian Tribe agreed to a lease for a mill site of 352.5 acres in secs. 1 and 2, T. 27 N., R. 37 E., and secs 35 and 36, T. 28 N., R. 37 E. within the Spokane Indian Reservation. A mining lease has been signed and awaits approval of an environmental impact statement for 552 acres in secs. 2 and 3, T. 27 N., R. 37 E., and secs 34 and 35, T. 28 N., R. 37 E. The mill site area and mine location includes portions of the original Peters Permit and Boyd Permit ground. Western Nuclear, Inc. also holds three mineral prospecting permits totalling 20,709.76 acres on the reservation.

Past production at the Northwest Uranium mine, now a part of Sherwood uranium project, was 187,300 tons containing 305,700 pounds of U_30_8; production ceased in March 1962. There is reportedly estimated 8 million tons of ore at the mine from which nearly 14 ton pounds of U_30_8 can be extracted over an 8 year period (Mining Record, 1974).

Lowley Lease

The Lowley lease area is 7 miles south of the Midnite mine in S ½ sec. 13, T. 27 N., R. 37 E. (Figure 5, no. 10). Autunite, uranophane, torbernite, and uraninite occur in fractured quartzite near a faulted contact with granite. Daybreak Uranium, Inc. explored the property by bulldozing, drilling, and a 60-foot inclined shaft with 400 feet of drifts (Huntting, 1956, p. 356). The better samples taken from 4-foot intervals in two drill holes contained 0.128 to 0.321 percent U_30_8. Production has been 285 tons from mineralized rock in the shaft; ore reserves are not known.

Bair Lease

The Bair Lease (Figure 5, no. 11) in the S¼ of sec. 14, T. 27 N. 7 E., was also held by Daybreak Uranium. A sample of veinlets across a 30-foot bulldozer cut is reported to have assayed 0.48 percent Uranium minerals are autunite and uraninite (Huntting, 1956, p.355).

Big Smoke Prospect

The Big Smoke prospect (Figure 5, no. 9) is in sec. 11, T. 27 N., E. Radioactive minerals occur in pyroclastic and sedimentary of the Gerome Andesite along a faulted contact with the diorite. The uranium occurs in and adjacent to carbonaceous that has been intensely sheared. Fifty-five tons was mined hipped but was too low-grade to be treated (Huntting, 1956, p. 355).

North Star Uranium Lease

The North Star Uranium Lease (Figure 5, no. 2) is in Lot 6, W½, SE¼, and E½, SW¼ sec. 23, T. 29 N., R. 38 E. Here the country rock is deeply weathered granite cut by a fault and fracture zone. Locally the fault and fracture zone is intruded by lamprophyre dikes. Open cuts expose sparsely disseminated, low-grade deposits of autunite along the fault-fracture zone, particularly in the locality of the lamprophyre dikes. The drilling and dozing did not reach the water table.

Deer Mountain Prospect

The Deer Mountain uranium prospect (Figure 5, no. 1) is in sec. 21, T. 29 N., R. 38 E.

along the contact between schist of the Togo formation and porphyritic quartz monzonite. The contact is marked by a zone of intensely sheared rock about 5 feet thick containing sparse small flakes of metaautunite and uranophane (Becraft and Weis, 1963, p. 67).

Lucky Charm Prospect

The Lucky Charm Uranium prospect (Figure 5, no. 5) reportedly lies in sec. 7, T. 28 N., R. 38 E., as well as the S½ sec. 23, T. 29 N., R. 38 E. northeast of the Midnite mine. "Good radioactivity" is reported. Autunite reported to occur along joints in altered basalt (Huntting, 1956, p. 356).

Others

The leases of both the Dahl Uranium mine (Figure 5, no. 6) and the Square Deal Mining & Milling Co. (Figure 5, no. 7) are reported to have been in sec. 13, T. 28 N., R. 37 E. and both are said to lie along the argillite-granite contact. Weak radioactivity was detected on the Dehl prospect ln holes drilled to 75 feet. In deeper hole an interval from 128 to 134 feet below the surface contained from 0.20 to 0.70 percent U_30_8. At the Square Deal prospect values of about 0.1 percent U308 along the contract were reported (Huntting, 1956, P. 356).

Metallic Mineral Occurrences

Reported occurrences of metallic minerals within the reservation include tungsten, with minor amounts of molybdenum, silver, copper, and bismuth; copper with silver, zinc, and gold; and silver with lead and some copper; antimony, zinc and gold; and two low-grade manganese deposits. Figure 6 indicates the locations of the following mines and prospects:

<u>Tungsten occurrence</u>
1. Germania Consolidated mine
2. Alluvium prospect
3. Sand Creek Prospect

<u>Copper-silver-gold occurrences</u>
4. Alberta property
5. O-Lo-lim property
6. Racetrack prospect

<u>Silver-lead-zinc occurrences</u>
7. Orazada property
8. Indian Trail property

<u>Manganese Occurrences</u>
9. Wellpinit deposit
10. Turtle Lake deposit

Tungsten

<u>Germania Consolidated mine</u>.--Tungsten occurs at the Germania Consolidated Mines, Inc. mine (Figure 6, no. 1) in secs. 23, 24, and 26, T.

29 N., R. 37 E. The ore minerals are mainly ferberite and lesser scheelite, in three quartz veins which rarely exceed 8 inches thick in quartz monzonite. Reportedly a representative sample assayed 0.39 percent tungsten trioxide, 0.19 percent molybdenum, 0.6 ounces silver. Developments consist of adits, a 220-foot shaft with drifts, and some stoping. Underground and surface workings total more than 3,400 feet. The veins have been mined from three levels. The property is idle. Tungsten production records of the Germania Consolidated mines are incomplete. From 1915 through 1917, only 22 units of WO_3 were reported. It is reported that $100,000 worth of feberite was produced prior to 1945 and that 561 units of WO_3 for which $34,704 was received were produced from 1951 to 1955. There are no known reserves of tungsten ore at the mine but the persistence of the veins and tungsten mineralization over a strike length of more than half a mile suggests a favorable target.

Sand Creek Tungsten.--Tungsten has been reported at the Sand Creek Tungsten prospect (Figure 6, no. 3) in sec. 3, T. 28 N., R. 37 E. The ore is variously reported as wolframite or as hubnerite with some molybdenite. It occurs in small quartz stringers as much as 18 inches thick in altered granite (Colville Engineering Co., 1943, p. 71). The workings consist of a 25-foot adit, open pits, and trenches. Production amounted to several sacks of ore in 1917 (Huntting, 1956, p. 349).

Alluvial tungsten (Figure 6, no. 2) of unknown quantity, occurs along a tributary to Sand Creek and down drainage from the Germania mine, in the SE¼ sec. 24, T. 29 N., R. 37 E and in the SW¼ sec. 19, T. 29 N., R. 38 E.

Copper

O-Lo-Lim mine.-- Chalcopyrite, pyrite, bornite, malachite, and tenured occur at the O-Lo-Lim mine (Figure 6, no. 5), SE¼, sec. 9, T. 28 N., R. 37 E. The minerals are in a quartz--tremolite vein ranging from 2 to 6 feet thick near a contact between argillite and quartzite. The mine was developed by a 100-foot shaft with 35- and 15-foot-long drifts at the bottom (Weaver, 1920, p. 223). The shaft is now caved, the workings inaccessible and the property has been abandoned. O-Lo-Lim mine production figures list smelter shipments of 277 tons of ore during the years 1915-1917 inclusive with yields of 337 ounces of silver and 44,943 pounds of copper. No ore reserves are reported.

Alberta prospect.--The Alberta prospect (Figure 6, no. 4) is in sec. 3, T. 28 N., R. 37 E. A quartz vein with an estimated average thickness of 15 feet has values in copper with some silver and gold. The vein is at or near a shale-argillite contact with granite. Two shallow shafts were sunk when the property was first leased during World War I. One was later extended to a depth of 90 feet and a crosscut was driven which intersected 18 feet of quartz mineralized with streaks of chalcopyrite principally on the footwall side. A specimen of the ore was reported by American Smelting and Refining Co. to contain 89 percent silica, 3.3 percent copper, and 1 ounce of silver per ton. The U. S. Bureau of Mines reported a specimen from the dump taken in 1943 contained 1.34 percent copper, 0.2 ounce silver, and 0.01 ounce gold (Huntting, 1956, p. 92). No production records or reserves are known.

Racetrack prospect.--The Racetrack copper prospect (Figure 6, no. 6) is said to be in sec. 7, T. 27 N., R. 38 E. Reportedly trespassers developed the prospect 70 years ago by sinking a shaft.

Silver

Orazada mine.--The Orazada mine (Figure 6, no. 7) contains narrow mineralized breccia zones in argillite and limestone. Well developed gossan is found on the surface, and at depth jamesonite, pyrite, arsenopyrite, galena, and sphalerite are in quartz, barite, and calcite gangue. The combined average value of the silver, lead, antimony, gold, and zinc ore is variously reported as $15.00 or $25.00 per ton. The mine is in the NW¼, sec. 27, T. 29 N., R. 37 E., and has been explored by two adits, one 3,000 feet long, and open cuts (Huntting, 1956, p. 330) (Colville Engineering Co., 1943, p. 67).

The Orazada property is credited with a shipment of 25 tons of ore to a smelter in 1927 which yielded 2 ounces of gold, 315 ounces silver and 6,677 pounds of copper. In 1941, a shipment of 10 tons of ore to a smelter contained 3 ounces of gold, 153 ounces of silver, 77 pounds of copper, and 697 pounds of lead. No information about ore reserves is available.

Indian Trail mine.--The Indian Trail mine (Figure 6, no. 8) is in the NE¼ sec. 31, T. 29 N., R. 36 E. Silver, lead, copper, zinc, gold, and some uranium is found in irregular veins and pods of metallic oxides and sulfides along fractures within argillite. The country rock is metasedimentary rock (largely argillite, quartzite, and marble) intruded by monzonite. Early work yielded values as much as 140 ounces silver, 0.17 ounce gold, 57.96 percent lead, and 5.76 percent copper per ton of ore. Later development revealed scattered mineralization in a 12- to 24-inch-thick quartz vein. The main adit is 325 feet long with 90 feet of crosscuts (Washington State Division of Mines and Geology, 1966). The Indian Trail mine reportedly produced several hundred tons of ore which was shipped to a smelter in 1968; results are unknown.

Manganese

Turtle Lake deposit.--The Turtle Lake (Figure 6, no. 10) deposit is in the SW¼, sec. 16, T. 28 N., R. 38 E. Manganese oxides cement weathered quartz monzonite to a 1- to 3-foot depth over an exposed area of 75,000 square feet. The rock contains an estimated 15 to 20 percent manganese dioxide (Becraft and Weis, 1963, p. 70).

Wellpinit deposit.--The Wellpinit manganese deposit (Figure 6, no. 9), is in the south center of sec. 24 and the north center of sec. 25, T. 29 N., R. 38 E., and has been the subject of a metallurgical investigation by the Washington State Institute of Technology. The manganese minerals are pyrolusite and psilomelane. A 13-foot vertical section contains several mineralized horizons: an upper 3 feet of a solid capping of manganese-bearing rock is underlain by 3 feet of barren arkosic sand. Below that there are alternating manganiferous and arkosic strata. The manganiferous bed average is 6 inches thick. Manganese-oxides occur with iron-oxides cementing disintegrated granite in an area approximately 600 feet wide and about 1,500 feet long. The deposit has been exposed by several trenches and open cuts. A 1,500-pound sample assayed 6.4 percent manganese and metallurgical work indicated that the manganese-bearing rock can be concentrated to 47-49 percent manganese (Crosby and Masson, 1955).

Nonmetallic Mineral Deposits

Reported nonmetallic minerals are barite, quartz, fibrous tremolite, sand and gravel, silica sand, marble, limestone, dolomite, and potassium feldspar. Their locations are shown on Figure 7 by an appropriate symbol. There are no production records and no reserve data for any of these minerals.

Barite

Barite occurs in sec. 22, T. 29 N., R. 37 E., as a 4-foot-thick vein in quartzite. The barite which makes up most of the vein is white, coarse, massive, and contains some pyrite. It has not been developed. Seven barite occurrences are known to the north a few miles from the reservation. Two of these deposits have production records. The barite occurs as vein ranging in thickness from a few inches to more than 6 feet. Additionally, barite is a gangue mineral in several copper deposits in the same area (Becraft and Weis, 1963, P. 71).

Quartz

A pegmatitic segregation of quartz in the Loon Lake granite is in the SW¼, sec. 31, T. 28 N., R. 38 E. The deposit is high-grade (99.4 to 99.8 percent SiO_2) but small, approximately 50 feet long by 40 feet wide by 25 feet plus in depth, representing about 4,200 tons. No other such quartz occurrences within the reservation are reported. A somewhat larger and similar quartz deposit is reported 3 miles off the reservation in sec. 6, T. 27 N., R. 37 E.

Some portions of the quartzite making up the upper part of the Togo formation are reported to be of high purity. Locally, portions of the Addy quartzite are also reported to be generally pure.

These quartzites crop out in secs. 4 and 9, T. 28 N., R. 37 E., in secs. 27 and 34, T. 29 N., R. 37 E., and in secs. 28 and 33, T. 29 N., R. 37 E. (Becraft and Weis, 1963, p. 8 and 12, pl. 1).

A wellsorted deposit of high purity quartz and quartzite pebbles is reported in sec. 8, T. 28 N., R. 36 E.

Fibrous Tremolite

The Boundary Butte fibrous tremolite deposit occurs in a prospect pit in the NW¼, sec. 21, T. 29 N., R. 37 E. (Valentine, 1949, p. 9). It occurs in a bed of altered dolomite 4 feet thick.

Sand and Gravel

Sand and gravel deposits are found at many sites throughout the reservation, but only two have produced; 1) a Department of Highways pit in the SE¼, sec. 4, T. 28 N., R. 40 E., and 2) the A. H. Timm pit at Ford, Washington. No information is available describing the quality, character, or extent of the deposits (Valentine, 1949, p. 87).

Silica Sand

The Lyons Hill (Marshall) deposit of high quality silica sand is less than a mile north of the reservation in sec. 13, T. 29 N., R. 39 E. (Jaekel and Sharp, 1948, p. 2).

Large areas along the northern side of the Spokane River are covered with reworked sands from glacial deposits. Along Sand Creek are large quantities of sand resulting from the weathering of quartzites in the area. The composition and quality of these sands is not known.

Limestone, Marble, and Dolomite

The Stensgar dolomite, as mapped extends into secs. 15 and 27, T. 29 N., 37 E. The Edna dolomite and the Old Dominion limestone extend into secs. 23, 27, 33, and 34, T. 29 N., R. 37 E. as well as secs. 4 and 9, 28 N., R. 37 E. and into secs. 20, 21, 28 and 29, T. 29 N., R. 37 E. Marble has been reported in the Old Dominion limestone near the northern boundary of the reservation and also in the cayuse Mountain area, secs. 19, 20, and 21, T. 27 N., R. 38 E. (Becraft and Weis, 1963, pl. 1).

Feldspar

Potassium feldspar is present in amounts varying between 25 and 35 percent of the large mass of porphyritic quartz monzonite lying in 38 sections northwest of Wellpinit (Becraft and Weis, 1963, p. 28 and map). Potassium feldspar makes up most of the abundant one-half to 2 inch phenocrysts. An equal amount of plagioclase is also present.

Fossil Fuels

Coal

The Orazada Creek coal deposit is in the NW¼, sec. 8, T. 28 N., R. 37 E. It is variously reported as a 3-foot coal seam or a zone of carbonaceous material in which are several small stringers of coal. Supposedly there were considerable underground and surface workings at one time, but they are caved and the property has been abandoned. Several wagon loads of this coal were hauled to the Creston area many years ago (Becraft and Weis, 1963, p. 71; Colville Engineering Report, 1943, p. 75-76).

POTENTIAL RESOURCES

Energy Resources

Uranium

The major potential as well as identified resource of the reservation is uranium. There is favorable evidence for the existence of undiscovered uranium resources in metamorphic rocks (Midnite mine type), and in volcaniclastic rocks (Northwest Uranium mine type).

Potential resources of uranium in deposits similar to the Midnite mine are relatively large. From experience gained in studies of the Midnite mine we can make some reasonable extrapolations to other areas. The Midnite mine had only a small surface radioactive expression, hence the failure to find more such deposits to date does not necessarily mean they do not exist. Exploration for this type of deposit is complicated by the fact that radiation surveys do not penetrate far beneath soil cover, a particular problem in heavily wooded north-facing slopes. Ore grades and total production from the Midnite mine have been larger than expected at the outset, hence there is some reason for optimism in evaluating the economic potential of prospects. A relatively large area of the reservation, about 10 square miles, is underlain by favorable Togo rocks which are near porphyritic quartz monzonite at depths of less than 1,000 feet; most of this area has been only superficially explored. Hypothetical orebodies can be expected to range from 50,000 to 4,000,000 tons of ore and contain from about 100,000 to 8,000,000 pounds of uranium oxide.

It seems unlikely that the Midnite mine should be the only one of its type in the belt of Togo Formation near the intrusive contact with the porphyritic quartz monzonite which extends from the Spokane River to near Waitts Lake. If there is a normal frequency distribution of large and small deposits in this belt, then one may hypothesize the existence of possibly one or more deposits as large or larger than at the Midnite mine, and a greater number of smaller size. Whether or not these deposits, if present, are found depends on factors such as depth, accessibility, and intensity of exploration effort.

Other uranium deposite similar to the Northwest (Sherwood) mine may occur in volcaniclastic rocks of the Gerome Andesite, but several factors weigh against the likelihood of discovering them. First, the conglomerate and carbonaceous rocks which are crucial for the ore environment are not typical of the Gerome, and less than a square mile of area is known to be underlain by these rocks. Secondly, these volcaniclastic rocks will tend to be water-saturated aquifers in areas other than those along the Spokane River bluff. Control and pumping of water could adversely affect the economic recoverability of new deposits recognized. And finally, there appears to be a tendency for deposits like the Northwest to be of low grade.

A more speculative potential resource of uranium is that which may occur in granitic rocks of the Loon Lake batholith. In theory there is potential for low grade (0.05 to 0.10 percent U_30_8) disseminations of uranium in granite. An important deposit of this type has been identified at Rossing, South Africa. Recent work by U.S.G.S. geologists indicate that some bodies of Loon Lake granite contain anomalous amounts of uranium, and perhaps somewhere on the Spokane Indian Reservation there might be found a large low-grade body that can be mined.

Coal, Oil and Gas

No significant potential resources of coal, oil, or gas are apparent on the reservation. Although thin coal seams are present between lava flows in the Gerome, they are not thick enough or extensive enough to be of economic importance. No rock units on the reservation can be considered as favorable reservoirs for oil or gas. Also, metamorphism has driven off carbon compounds or converted them to graphite, hence there are no appropriate source rocks for oil or gas.

Metallic Resources

Potential for resources of metals is greatest for copper, molybdenum, tungsten, lead, zinc, and silver. There has been some production of these metals in the area, so possibly unidentified resources may be present.

Copper

Copper may be found in fault and shear zones in Precambrian metamorphic rocks similar to the O-Lo-Lim mine. At the surface, the copper would probably be in oxidized minerals as at the Alberta prospect. A much more speculative resource of copper is in low grade deposits disseminated in granitic rock of the Loon Lake batholith. Some of the granite plutons are similar in age and character to those in British Columbia which host important porphyry copper deposits. There have been no discoveries to date of porphyry copper deposits in northeastern Washington, but igneous rocks in this large area are only now beginning to be examined for this type of deposit.

Molybdenum and Tungsten

Molybdenum and tungsten have been mined at several places in the area and are frequently detected. Deposits of tungsten, with lesser amounts of molybdenum, in veins as at the Germania Consolidated mine, might exist, but are economically unfavorable because of their small size and difficult mining conditions.

Lead, Zinc, and Silver

Vein deposits containing lead, zinc, and silver might be found in metamorphosed Precambrian or Paleozoic rocks. Silver is likely to be the key metal if a base metal deposit is relatively rich in silver it may become especially attractive. Silver-rich deposits similar to that of the Orozada mine might be found in shear zones.

Others

Deposits containing antimony, arsenic, gold, iron, and manganese are known in the area. Antimony and arsenic could be produced as by-products from a base-metal mine. Iron deposits in the form of magnetite are known in contact metamorphic replacements of limestone less than a mile north of the reservation boundary. The magnetite bodies apparently are too small to be economic. Manganese deposits occur in weathered granite 7 miles north of Wellpinit and 1 mile south of Turtle Lake but are not of sufficient size or grade to be economic.

COMMODITY MARKETING

Most of the following marketing information and statistics are from U. S. Bureau of Mines (1975), Anderson (1963), Nuclear Exchange Corp. (1975), Metals Week (1975), and Ore Buyers Guide (1974).

Uranium

In 1974, uranium production and consumption in the United States were both about 11,600 tons of U_30_8. However, about 7,800 tons of U_30_8 in the form of concentrates and other compounds were imported as compared to an export of 2,200 tons. The primary demand for U_30_8 was for nuclear fuels which totalled an estimated 11,600 tons. Non-nuclear uses totaled about 1,000 tons for ballast, counterweights, shielding, alloys, catalysts, glass colorant, and electrical components. The average price per pound of U_30_8 was $10.50 during 1974, but late in the year the price increased to the current $16.00 level. Initially, the A.E.C. (now Energy Resources and Development Administration, ERDA) purchased the uranium concentrates produced from the deposits upon the reservation. Presently the largest sales are to electric utility companies for use in their atomic power plants.

For the past few years the Dawn Mining Company's entire production from the Midnite mine has been purchased by General Public Utility Corp. of New York, New Jersey, and Pennsylvania at a price ranging from $7.10 to

\$9.85 as of January 1975. Four million pounds of U_30_8 will have been delivered to them by July 1976 when the present contract expires. A recent press release stated that Dawn Mining Co. had made a spot sale of 400,000 pounds of yellowcake to Kraftwerk Union (KWU), West Germany. The sale price was not stated.

By April 1975 the uranium market was at a standstill. For the first time in almost two years, there was no change during the month of March in the immediate delivery price for yellowcake.

There are bids for a large volume of material for delivery at \$16 per pound but the offering price is at \$2 to \$4 per pounds above this figure. Current transactions (3,200,000 - 4,100,000 pounds of U_30_8) for delivery in 1975-1985 range from 20 percent below to 10 percent above the current Nuclear Exchange Corp. value of \$16 per pound. The limited (150,000 - 400,000 pound) transactions for delivery in 1975 are at \$16 per pound.

Although the Exchange products a value of \$18.30 per pound of U_30_8 for July 1, 1976, and as much as \$30.10 per pound by July 1, 1980, there are a number of circumstances which can materially mitigate the latter value. The numerous atomic reactor plant deferrals and some outright cancellations due to tight money, environmental objections, and lower forecasts for future load growth cause a lower domestic uranium demand than previously anticipated.

Consumer inventories are at an all time high of 25,000 tons of U_30_8 which is equal to two years of domestic production at the 1974 rate. Additionally, there are negotiations, prompted by lower costs, proceeding towards the assignment of a substantial number of domestic enrichment contracts to foreign utilities, some of which have already contracted for their uranium supply.

Tungsten

Fifty-five percent or more of the tungsten consumption is for cutting and wear-resistant materials such as tungsten carbide. Specialty tool steels and mill products consumed 26 percent, welding and hard facing rod consumed 7 percent, with superalloys, chemical and ceramic, and other uses comprise the balance.

During the past few years prices have ranged from \$78.00 per short ton unit of 65 percent WO_3 concentrates in 1970 to a low of \$34.00 per short ton unit in 1972 and back to an all-time high of \$105.00 per short ton unit in the fall of 1974. The price in early 1975 was \$94.00 per short ton unit.

A ready market for tungsten concentrates presently exists. The Nevada Division of Kennametal Inc., Fallon, Nevada is the purchaser and processer nearest to the Spokane reservation.

Silver

Photography is the largest consumer of silver, closely followed by sterling ware and electroplated ware, in turn followed by electrical and electronic products, the brazing alloys and solders, jewelry, catalysts, dental and medical supplies, mirrors, etc.

The price of silver reached a historic high of $6.70 per troy ounce on February 26, 1974. Since then it has fluctuated between $4.00 and $4.60.

Silver-lead-zinc ores are still being purchased by the Bunker Hill concentrator and concentrates are being accepted by the smelter at Kellogg, Idaho. However, concentrates cannot contain more than 0.6 percent copper to be acceptable by the smelter.

Copper

Approximately 61 percent of all copper produced (primary and secondary) is used in electrical applications, 14 percent is used in construction, 10 percent in industrial machinery, 8 percent in transportation, 2 percent in ordnance and the balance in miscellaneous.

During the past 5 years, copper prices have averaged from a low of 51.2 cents in 1972 to a high of 86.6 cents per pound in 1974. Early in 1975 the price was 63.4 cents per pound.

The sale of copper concentrates currently presents a problem. Formerly copper concentrates with silver and gold values was readily accepted at the ASARCO Smelter, Tacoma, Washington. Recently ASARCO has been accepting siliceous copper ores containing silver and gold more readily than new sources of copper concentrates. The Anaconda Copper Company smelter at Anaconda, Montana, still accepts custom concentrates.

Lead

Approximately 64 percent of all lead consumed in the United States is for batteries and gasoline additives; 8 percent for electrical uses; 6 percent for construction; 7 percent for paints; and 5 percent for ammunition.

Prices during the last 5 years have averaged from a low in 1971 of 13.9 cents per pound to a high of 25.5 cents late in 1974. In early 1975, the price was 24.5 cents per pound.

Zinc

Major uses of zinc are: diecasting alloys, 40 percent; galvanizing 36 percent; and brass products, 14 percent. More than 250,000 tons of zinc oxide used for pigments and compounds are produced annually which are not included in the above figures.

Since 1969, the average annual zinc price has increased steadily from 14.7 cents per pound to an all-time high of 39.9 cents per pound in December 1974. Early in 1975 the price was stable at about 38.5 cents per pound.

See the section on silver for marketing of zinc concentrates.

Antimony

Uses for antimony are: antimonial lead for batteries, the manufacture of plastics, the preparation of flameproof compounds, the production of ceramics and glass, as an opacifier in enamel frit, and in a number of smaller consumption areas such as bearings, pigments, type metal, rubber products, solder, ammunition, and others.

The United States imports more antimony metal and materials than it produces domestically from primary sources.

Prices have fluctuated widely during the past 5 years, from an all-time high of $40.00 per short ton unit of 60 percent lump ore and concentrate in 1970 to a low of $8.64 per short ton unit in 1971 and back to a high of $38.00 in 1974. Early in 1975 the price was $21.00 per short ton unit.

Antimony concentrates are being accepted for purchase at the Sunshine Mining Co. antimony plant near Kellogg, Idaho.

Molybdenum

Over 80 percent of the molybdenum is consumed by the iron and steel industry for alloying. The next largest use is as a lubricant. A small amount is used as a pigment in paint.

The average price in 1974 was $2.30 per pound (molybdenum in concentrates) but at the end of the year the price was $2.43 per pound.

Manganese

There was no recorded production of manganese ore in the United States during 1974. An estimated 1 million tons of ore and 450,000 tons of ferromanganese were shipped from government stockpiles. Imports amounted to 1,200,000 tons of ore and 370,000 tons of ferromanganese. Domestic consumption was about 1,800,000 tons of ore and 1,075,000 tons of ferromanganese.

Manganese alloys, metal, pig iron and steel represents more than 90 percent of the annual consumption. Less than 10 percent is consumed in dry cell batteries, chemicals, and miscellaneous uses.

The price during 1974 ranged from a low of $0.80 to a high of $0.95 per long ton unit of contained manganese in 46-48 percent manganese metallurgical ore (cost, insurance, and freight), U. S. ports, duty extra.

The largest market for manganese is the iron and steel industry. In the west, Kaiser Steel Corp. Oakland, California and Oregon Steel Mills, Portland, Oregon, are potential markets.

Gold

Mine production in the United States during 1974 was about 1,120,000 troy ounces. This represents the fourth straight drop in production in as many years. Imports amounted to 2,800,000 troy ounces. Consumption was down to 4,200,000 troy ounces, a reduction of 2 ½ million troy ounces from 1973.

Jewelry and the arts consumed 49 percent; other industrial uses, including space and defense needs 39 percent; and dental, 12 percent.

The average price during 1974 was $161.08 per troy ounce; however, a historic domestic high of $195.25 per troy ounces was recorded on December 30, 1974. The price in early 1975 is fluctuating between $164.00 and $183.00 per troy ounce.

Agricultural Limestone and Dolomite

Markets for agricultural limestone and dolomite exist in the Deer Park area, the Spokane Valley, the Colville Valley, the Columbia Basin in Washington, the Willamette Valley or Oregon, and along the western slope of the Cascades in both Oregon and Washington.

The agricultural limestone and dolomite resource potential is good. The Spokane Tribe of Indians may find advisable to investigate the feasibility of establishing their own soil sweetener and fertilizer operation. Much of the agricultural land on the reservation has resulted from the clearing of coniferous trees. Usually such soils are acid and need sweetening (a higher pH) as accomplished by the addition of agricultural limestone and/or dolomite (as indicated by soil testing) ln order to achieve greater economic productivity of grasse and/or grains.

With the limestone and dolomite deposits on the reservation as a base, additions of four trace elements (copper, zinc, molybdenum, and manganese) and potash feldspar, all found on the reservation, could be made. Nitrogen in ammonium phosphate and ammonium sulfate could be purchased and blended as required to produce a very beneficial fertilizer. Such a project could be tribally owned and operated for the benefit of reservation lands; however, outlets for the products might be established in the Spokane, Lewiston, Idaho, and Columbia Basin areas, or the product could be supplied to the other reservations.

Marble

There is no information available for the production and consumption of marble chips, roofing granules, terrazzo particles, and other products.

The local price is about $31 per ton bagged, f.o.b. plant for average material. Special natural colors and special sizes command higher prices.

Marble chips and granules are shipped from Stevens County, Washington to markets in California, western Washington and Oregon, British Columbia and Utah.

The marble potential depends largely upon the occurrence of uncommon colors. There is a continuing good demand for naturally colored green marble to be used in terrazzo. Good intensity black marble is also in demand. Other unique or unusual colors probably would find a ready market.

Feldspar

Feldspar production in the U. S. is estimated to have been 790,000 tons for 1974. Apparent consumption was 730,000 tons. Fifty percent was for making glass, 40 percent for ceramics, and 10 percent for coatings, porcelain enamel, and other products.

During 1974 the average price for feldspar was $17 per ton, but 1975 quotations vary from $16 to $32 per ton, depending upon particle size and grade.

Feldspar is in demand by Northwest Glass Co. of Seattle, Washington. Additionally, there are markets in California and Alberta, Canada.

The U. S. Bureau of Mines believes that the feldspar in the porphyritic quartz monzonite found just west of Wellpinit and in the Turtle Lake area may have potential if the porphyritic character and percentages of potash and sodium feldspar are generally as described and mapped. The only feldspar reported being produced in the northwest is from feldspathic sands and is used in the manufacture of amber glass products.

Silica Sand

Approximately 35 percent of industrial sand is consumed in making glass of all types, about 25 percent is used as molding sand, 16 percent for ground sand, and 7 ½ percent is used as blast and furnace sand. The balance is used for filtration, grinding and polishing, traction, oil hydrofac, and others.

Silica sands used for glass, water glass, silicon carbide, grinding and polishing, filtration, etc., are generally purchased under contract and prices are subject to negotiations. Locally, the price is at least $7.10 per ton f.o.b. mine plant.

High purity silica sand is purchased by the National Carbide Carborundum plant at Vancouver, Washington, by the Ohio Ferro Alloys Corp. plant in Tacoma, Washington, and by the Philadelphia Quartz Co. of Tacoma, Washington. Lower quality sands are marketable for filtering plants, as molding sands, as asphalt admix and other uses.

Barite

About 83 percent of the barite produced is used as a weighting agent in oil and gas-well drilling muds. Other uses include applications in paints, glass, rubber, and chemicals.

The average price during 1974 was $16.50 per ton, but early 1975 quotations ranged from $15 to $80, depending upon grade and size.

A good market for high density, good quality barite continues to exist. Manufacturers Minerals Co. of Renton, Washington, is an agent for the sale of barite. The Inorganic Chemicals Division of FMA Corp., Modesto, California, is another possible market. Northwest Talc and Magnesium Co., Clear Lake, Washington, has custom barite grinding capabilities.

The barite potential depends upon the density, purity and size of the deposits. The reported occurrences on the reservation have an unknown potential.

Quartz

High purity quartz and quartzite are much in demand at the various ferrosilicon and silicon metal producing plants in the region including the Hanna Mining Co. plant at Wenatchee, and the Alcoa plant at Addy, Washington.

The quartz potential on the reservation is quite limited unless future mining operations uncover more pegmatitic segregation. The presently known quartz deposit, because of its small size, awaits a very special usage demand at a somewhat elevated price per ton. If segments of the Togo quartzite are of sufficient purity, they may have potential. Deposits of well-sorted quartz and quartzite pebbles ½ to 1 ½ inches in diameter found in the western part of the reservation may have potential also.

Fibrous Tremolite

Fibrous tremolite may be useful as a filtering medium for acid solutions and for other acidic environment usages. It may also be used as a filler. Tremolite asbestos has not been competitive with chrysotile, the more flexible asbestos. The resource potential of fibrous tremolite on the reservation is not known.

Sand and Gravel

Fifty-six percent of domestic consumption of sand and gravel was for highway and street construction. Thirty-nine percent went into general building and other heavy construction. The remaining 5 percent was used for glass, molding, abrasive sands, and other miscellaneous uses.

The average price for 1974 is reported as $1.61 per ton. The wholesale price in Spokane is $4.75 per ton or $8.31 per cubic yard.

Sand and gravel deposits are large and plentiful on the reservation. The deposits have potential, but at the present only for limited local usage. A concrete products plant might be established by the tribe to produce concrete blocks, cesspool chambers, concrete pipes, and other items for local usage and for sale in the surrounding area.

MINING AND EXTRACTION

Uranium

The uranium mining and extraction operations at the Dawn Mining Co. and the proposed operation by Western Nuclear, Inc. are described in the radioactive minerals section of this report.

Tungsten

Tungsten mining at the Germania Consolidated properties has required a little timbering.

The granitic country rock stands well so most drift and crosscuts are open with timbering only at fault or shear zones. The shrinkage stope method of mining has been used with stulls and headboards as occasionally required. Any future underground operations would be substantially the same.

There may be areas of eluvium along the strike of the vein outcrops which could be mined by use of a dozer and front-end loader. Additionally there may be placer tungsten values along the Owl Creek drainage in sec. 26, T. 29 N., R. 37 E., which could be mined by means of a backhoe and/or front-end loader with mineral jig concentration.

Extraction of the tungsten minerals has been by gravity methods in the past. Any future operations should include secondary rolls crushing to minus one-fourth inch, followed by screening to a plus 10-mesh fraction, a minus 10-mesh plus 35-mesh fraction and a minus 35-mesh fraction. The two coarse fractions would be fed to properly prepared and adjusted mineral jigs (not a harmonic motion jig) and the minus 35-mesh material would be fed to a hydraulic classifier with resulting fractions being fed to concentrating tables or spirals. Each of the jig concentrates should be cleaned magnetically. The minus 35-mesh concentrates should be cleaned by flotation to remove molybdenite, pyrite, and other sulfides. Depending upon the amount of sulfur present, the various concentrates may need to be dried and roasted for 20 minutes at 700 C to oxidize enough sulfur to meet specifications. Tailings from the two jigging operations might need to be further crushed and treated with the minus 35-mesh fraction if the tailings assays are not acceptable. Depending upon the quantity present and the price, a byproduct recovery of the molybdenite might be made by flotation.

Using the above procedure and equipment, a 91-percent recovery with a final concentrate grade of 66 percent $W0_3$ can be expected on Germania type ore (Floyd and Stickney. 1954. D. 1-6).

Copper-silver

Previous copper-silver mining operations were by shaft entry with drifts and crosscuts on more than one level. The actual stopping methods used are unknown. Any future mining should consider inclined entry and trackless mining. The earlier mined ore was quartz with 8 percent copper and 1.2 ounce silver per ton. Unless a very large tonnage can be blocked out it would be advisable to ship such crude ore to the smelter with no milling and a minimum of handsorting.

Silver-lead-zinc-antimony-gold

The two mines carrying this suite of metals were previously operated through several adit-drifts. Trackless mining would be advantageous if an inclined entry could be developed. Ore shipped in the past is not of the mineralogical character that can now be domestically shipped directly to a smelter. Any operation in the near future will require adequate ore reserves to justify a differential flotation milling facility unless a custom milling operation can be arranged.

Nonmetallic Minerals

If agricultural limestone and dolomite, marble, feldspar or quartz operations are developed, mining will probably be by conventional open pit methods. In the case of agricultural limestone and dolomite, the stone would be crushed by means of jaw and gyratory crushers to minus three-fourths inch. Dry finish grinding to 80 percent minus 65-mesh would be by means of air-swept hammermill or rod mill with attendant cyclone collectors. The preparation of marble would be by means of jaw crushers, ribbon-fed rolls and screens. A feldspar operation would probably involve jaw crushing followed by an impact crusher with screening to take advantage of differential crushing effects. The undersize from the impact crushing would be wet ground in a ball mill and the feldspar recovered by flotation.

Quartz would probably be jaw crushed to minus 2 ½ inch size and the minus l-inch material screened out. The plus l-inch material would be washed and shipped to ferrosilicon plants. The minus l-inch material would also be washed and further screened to remove any dirt and organic material prior to shipment for use in the manufacture of carborundum or for decorative rock or roofing material, or other uses.

Nearby barite deposits which have been worked have been surface stripped and underhand mined as much as possible but with some underground face mining and overhead stoping. This same procedure would probably be followed at any barite property developed on the reservation. Other than minor handsorting and cobbing the barite would be shipped as mined (Moen, 1962, p. 43).

There is insufficient information about the coal occurrence and previous operations to make any judgment about either the mining method or bonification needs.

Sand and gravel operations have been generally standard for small operations and probably will continue in the same manner.

TRANSPORTATION

Most of the Spokane Indian Reservation is readily accessible from a network of surfaced and improved gravel roads. State highways cross the western and eastern parts of the reservation. Within the reservation an all weather road joins Ford with Wellprint and extends north-westerly across the northern boundary; another joins the latter with Springdale; and a fourth main road leads from Wellpinit to the Spokane River and either to Ford or Reardan. From these principal roads, secondary roads branch in many directions leaving only a few areas of 4 to 6 square miles without vehicular access. The terrain and climate make even unimproved roads usable throughout much of the year.

A few private airstrips have been built on the reservation but additional work would be required on the fields before they could be used for air freighting. A number of additional good airfield sites exist on the reservation.

The nearest rail service is provided by a branch line of the Burlington Northern Railway System, serving Sprindale 16 miles northeast of Wellpinit. The branch joins the main east-west line at Spokane. The main line also serves Reardan and Davenport south of the reservation.

Transportation costs are rising at a rapid rate. For example, the railway tariff on shipping drums of yellowcake increased by 40 percent from early 1974 to mid-1975.

ENVIRONMENTAL AND SOCIAL ASPECTS

A 1970 survey indicated that the population density of the Spokane Indian Reservation was roughly 2.5 persons per square mile. However, most of the population is concentrated in the area surrounding Wellpinit, in the area near Ford, and in the more western areas near the Columbia River.

Combined residential, public and commercial-industrial land usage makes up 0.3 percent of the reservations's 137,002 acres. Roads take 0.6 percent; agriculture uses 4.7 percent; grazing uses 16.8 percent; and 77.6 percent is timbered and in multiple use, mainly for recreation. Productive mines have used about 0.45 percent of reservation lands. Nineteen percent of reservation lands are under lease and prospecting permit agreements. About 15 percent of the reservation lands are leased by Western Nuclear, Inc.

Mining on the reservation has caused essentially no change in the air and water quality. Of the 691.27 acres of land held under a uranium mining lease by Dawn Mining Co., not more than 25 percent of the surface has been disturbed. The surface disturbance, consisting of an open pit and auxiliary roads, is insignificant compared to the existing highways constructed through the reservation.

Probably traffic on unpaved roads throughout the reservation adds far more particulate matter to the air than a number of open pit operations such as the Midnite mine.

In 1973 there were roughly 1,420 people of Indian descent living on and adjacent to the Spokane Indian Reservation; 770 were on the reservation and 650 adjacent to it. Of this total, 451 constitute the available workforce. This workforce included 174 Indian workers (38 percent) permanently employed, 277 (61 percent) either underemployed or unemployed. A few of those considered permanently employed obtain their livelihood by operating small farms on the reservation as well as working part-time off the reservation to supplement their income.

Dawn Mining Co.'s Midnite mine and Ford uranium extraction plant provide employment for approximately 24 Indian people. Additionally the company paid $169,541.18 in royalties for the July 1, 1974 January 1975 period to the Spokane Indian Tribe and to individual members of the tribe. Further, it distributed dividends amounting to more than $1 million, a portion of which returned to members of the tribe through their ownership of Midnite Mines, Inc. stock.

The proposed Sherwood mine operation of Western Nuclear, Inc. will yield an estimated $400,000 annually to the tribe in royalty, and other fees as well as provide employment for about 50 Indian workers.

If an agricultural limestone and dolomite operation was established it might afford employment for 6 to 12 Indian workers. About the same number of jobs would be created if a feldspar operation is established.

RECOMMENDATIONS FOR FURTHER WORK

This review of available geologic information on the Spokane Reservation indicates that the general state of geologic knowledge is relatively good. Gaps in the knowledge exist in the general geology of the western third of the reservation and in details of mineral occurrences.

Studies underway by the U. S. Geological Survey should clarify the geology, geochemistry, and geophysics of the Midnite mine area and the belt of the Togo rocks extending northeastward from the mine. Results of these studies will be made available as soon as the data are compiled and evaluated. Of particular importance to uranium resource evaluation is a low altitude radiation survey to be undertaken in the summer or fall of 1975.

A major area of geologic undertainty is the approximately 30 square miles of reservation included on the Lincoln 15 minute topographic map that has not been mapped since about 1920. This area contains a variety of rocks ranging in age from Cambrian to Holocene, and probably has many structural complications from major fault zones. Based on mapping to the north, we may expect a complex sequence of shale, sandstones, graywackes, and limestones which have been faulted and intruded by Loon Lake granite. Extensive cover by glacial deposits obscures bedrock geology.

It is recommended that each known mineral occurrence on the reservation be mapped and sampled and geochemical and geophysical investigations test for possible extensions of known mineralized zones. Current studies of the uranium deposits by the USGS and private companies are believed to be adequate.

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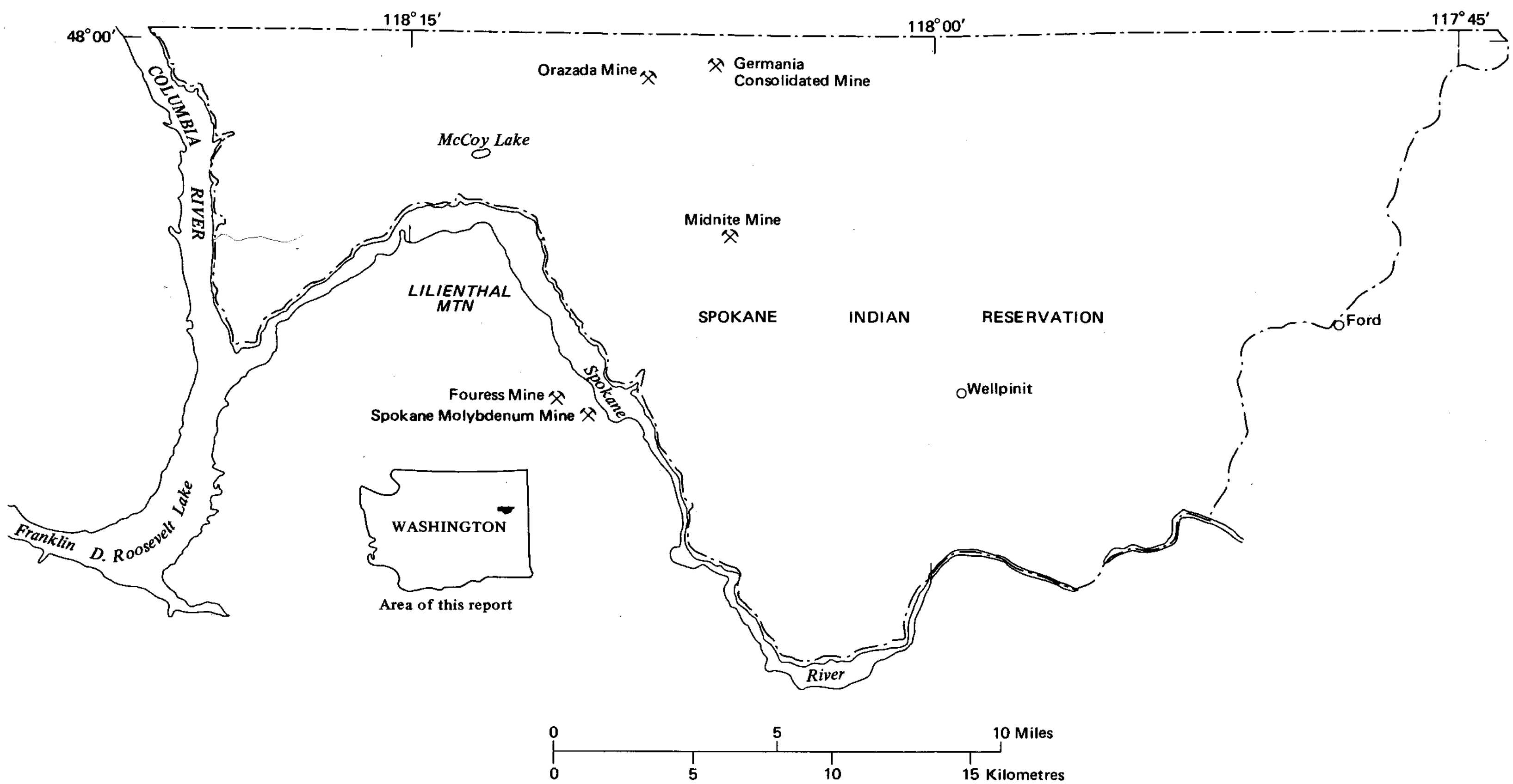

Figure 1. Index map of the Spokane Indian Reservation.

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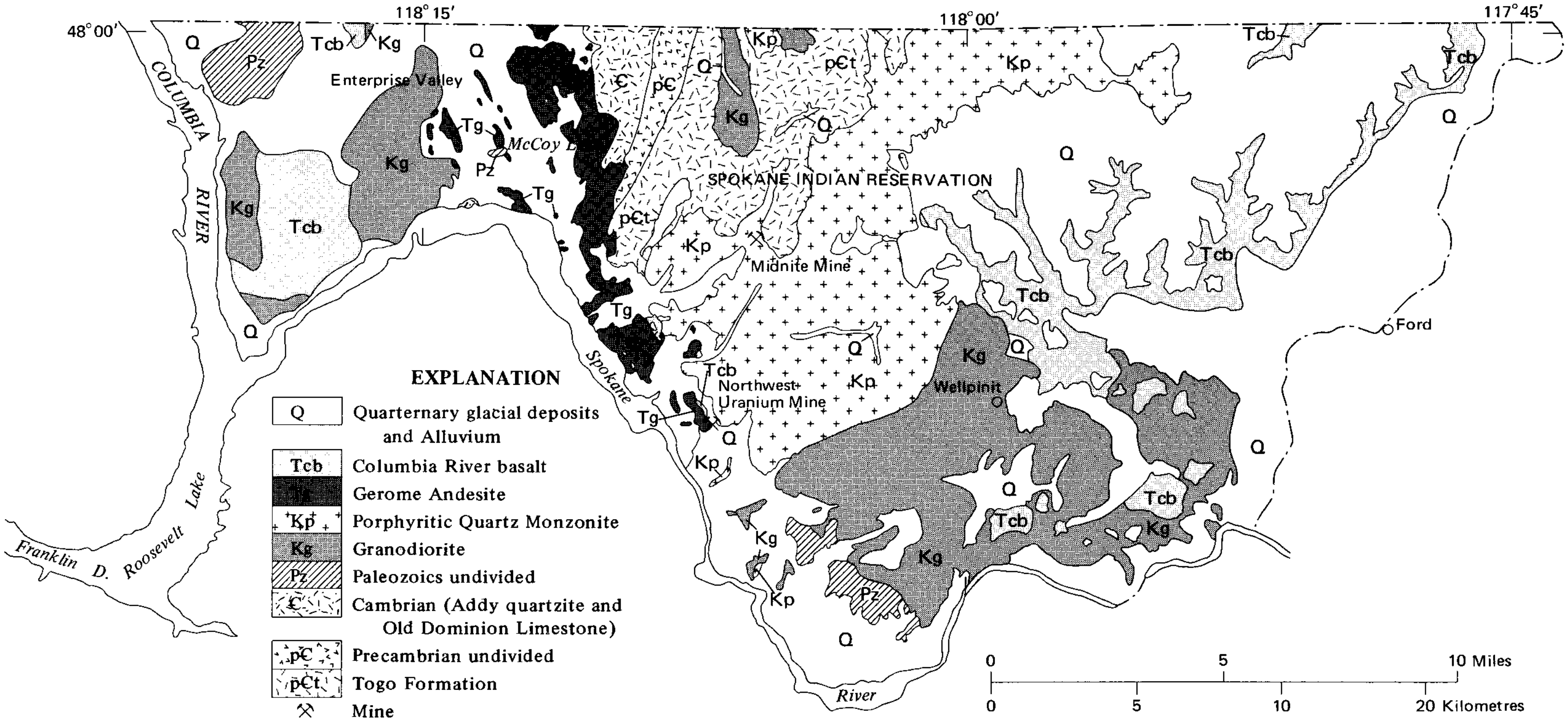

Figure 2. Generalized geologic map of the Spokane Indian Reservation.

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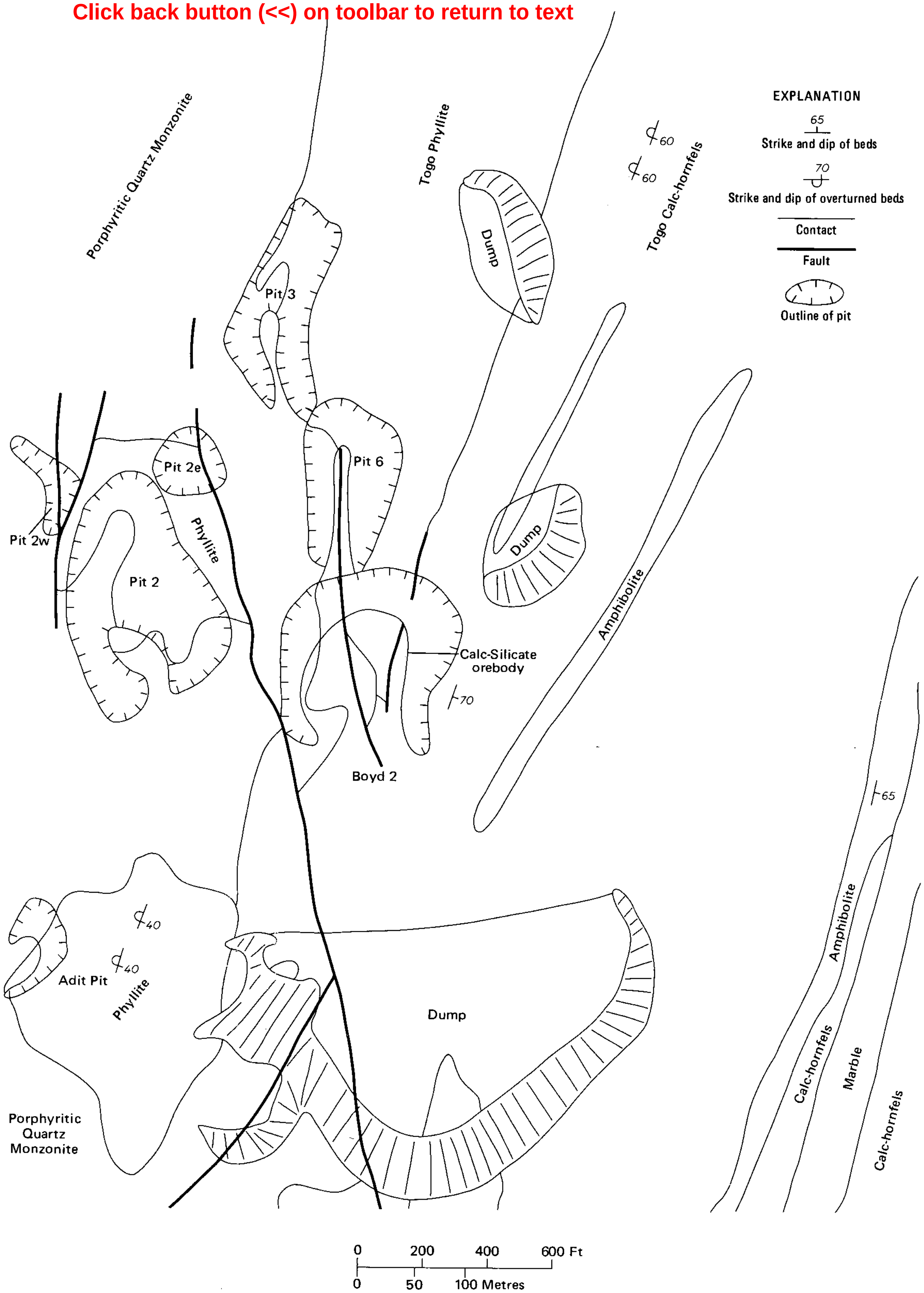

Figure 3. Geologic sketch map of the Midnite Mine area.

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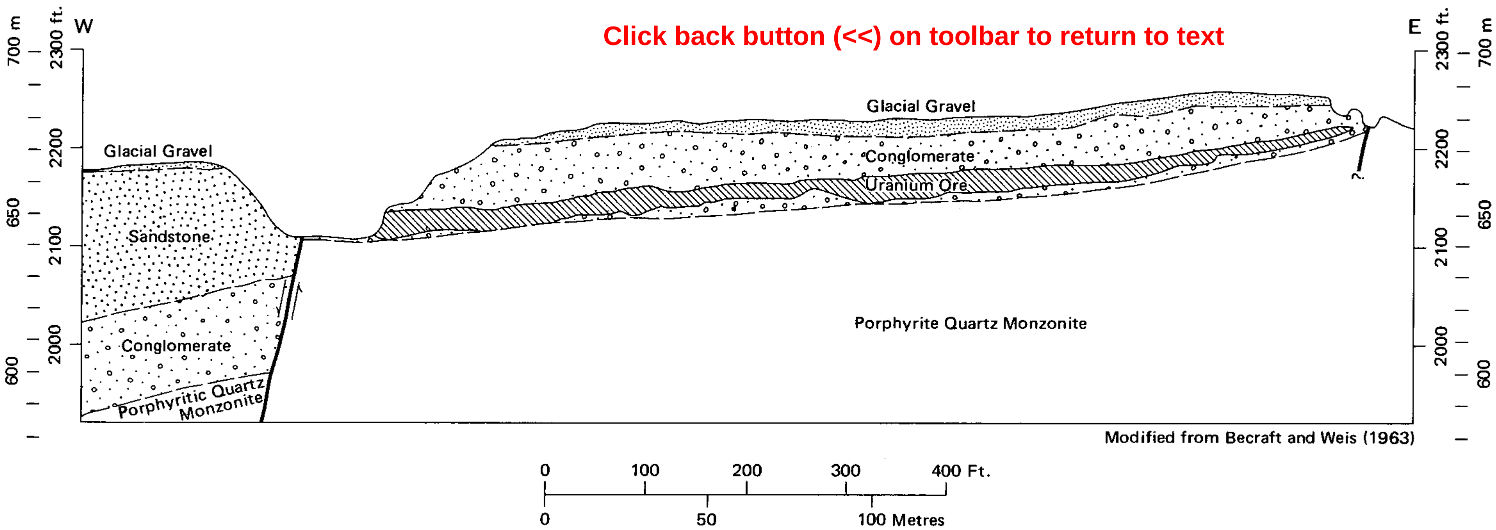

Figure 4. Cross-section of the Northwest (Sherwood) Uranium mine.

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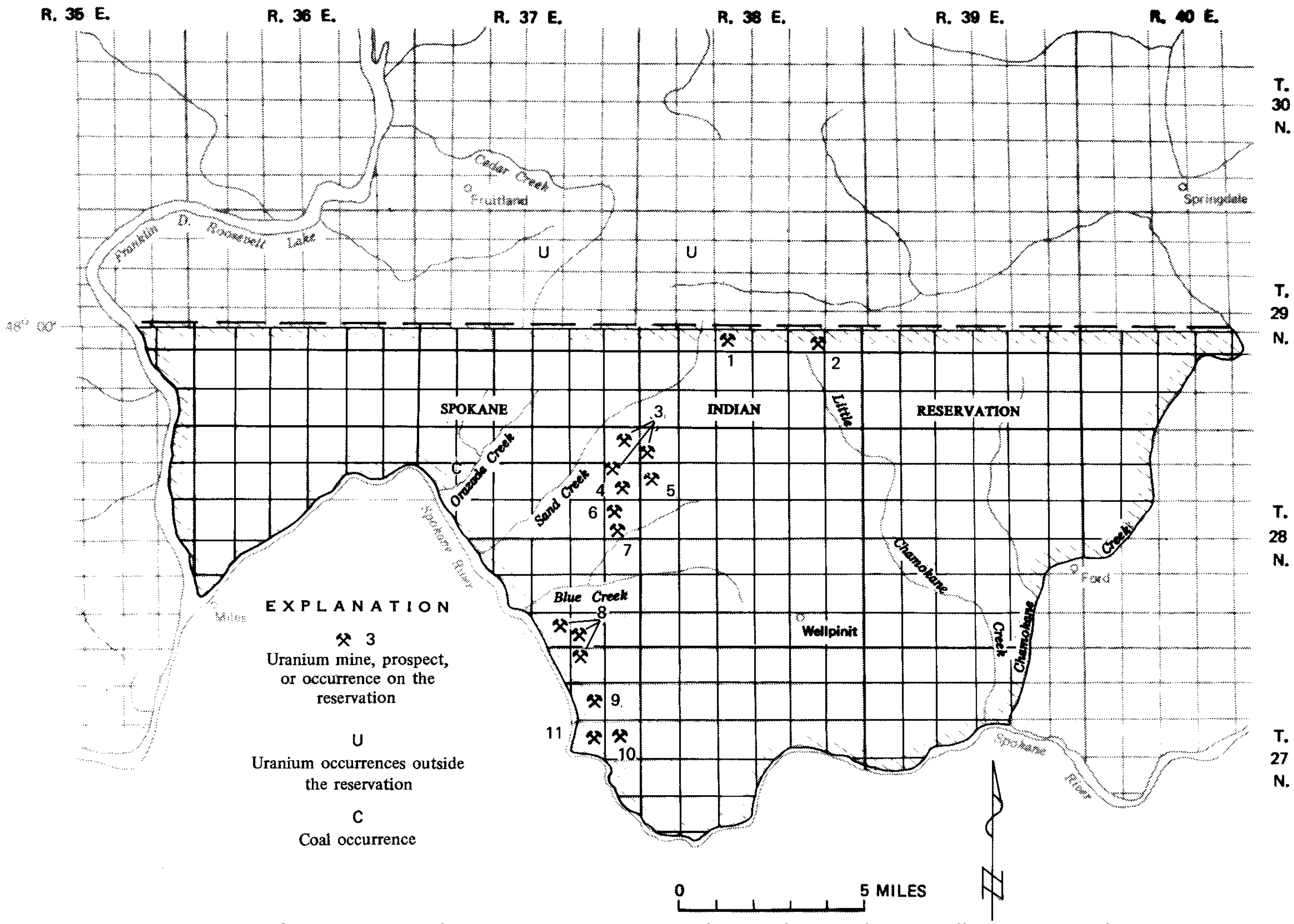

Figure 5. Uranium occurrences on and near the Spokane Indian Reservation.

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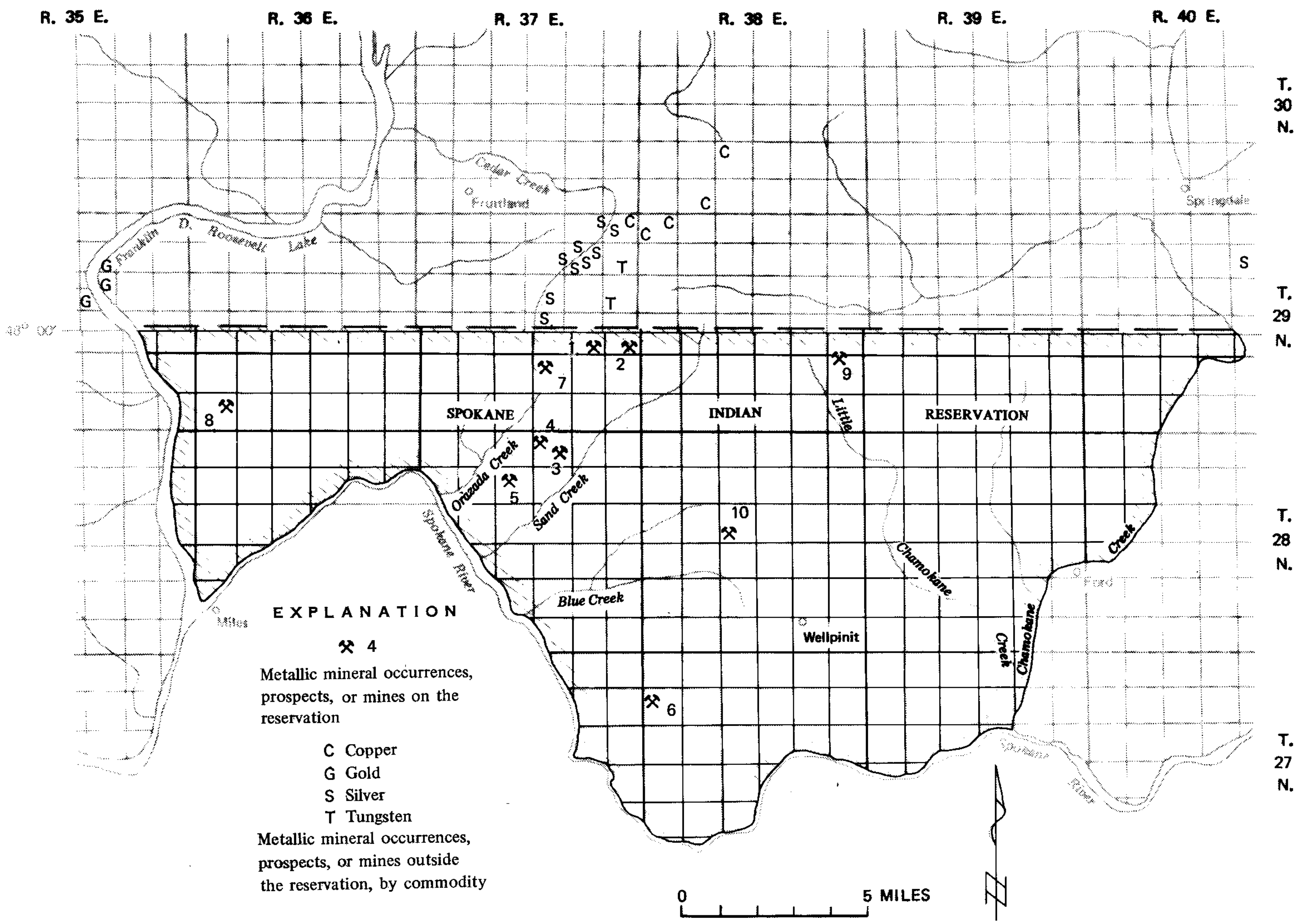

Figure 6. Metallic mineral occurrences on and near the Spokane Indian Reservation.

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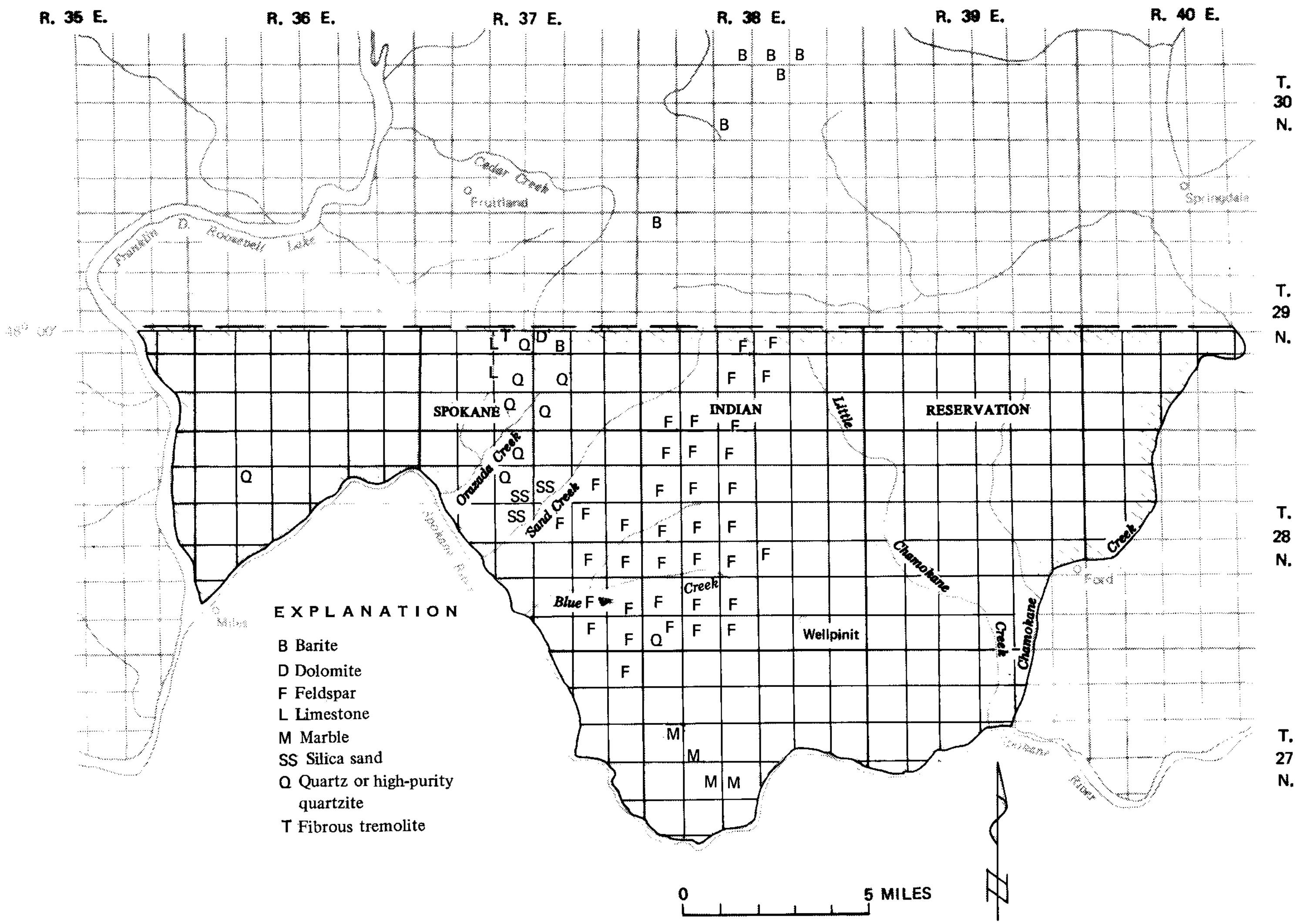

Figure 7. Nonmetallic mineral deposits on the Spokane Indian Reservation.